Evaluating the spectral dependence of geometry-dependent Lambertian-equivalent reflectivity (GLER) over the Oceans using OMI L1b measurements

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Introduction

- Surface reflectivity plays an important role in cloud and trace gas retrievals
- Climatological LER used in most trace gas retrievals do not account for variations in ocean surface roughness or satellite viewing geometry
- Geometry-dependent LER (GLER) captures these effects for current satellite algorithms with limited modifications (Vasilkov et al. 2017)
- This work evaluates GLER for water surfaces (Fasnacht et al. 2019, *in review*); GLER for land surfaces was evaluated by Qin et al. 2019

Methods

- The Vector Linearized Discrete Ordinate Radiative Transfer (VLIDORT) model (Spurr, 2006) is used to calculate sun-normalized radiances with a Case 1 water model for model water leaving radiances and Cox and Munk (1954) for ocean surface reflectance.
  - Water model inputs shown in Table 1
- LER derived from OMI normalized radiances are compared with GLER and Kleipool LER for mostly cloud and aerosol free scenes.
- All OMI measurements are from the OMI VIS channel.
- OMI Raman cloud (OMCLDRR) and aerosol (OMAERUV) products are used to screen data in Figs 1-4: cloud fraction (ECF) = 0, UV AI < 0.5
- Only deep Pacific Ocean data were analyzed (deep ocean pixels determined based on OMI L1b flags) to reduce including Case 2 waters.

Model Input	Source	Dates Used
Chlorophyll	Moderate Resolution Imaging Spectrometer (MODIS) (EOS Aqua)	Entire OMI Mission
Wind Speed	Advanced Microwave Scanning Radiometer (AMSR-E) (EOS Aqua)	OMI Launch – Oct 2011
Wind Speed	Special Sensor Microwave Imager/Sounder (SSMIS) - Defense Meteorological Satellite F16	Oct 2011 – present
Wind Speed (satellite gap filling)	NASA's GEOS-5 Forward Processing for Instrument Teams (FP-IT)	Entire OMI Mission
Wind Direction	NASA's GEOS-5 FP-IT	Entire OMI Mission

Table 1: Data sources for water model simulations

Results

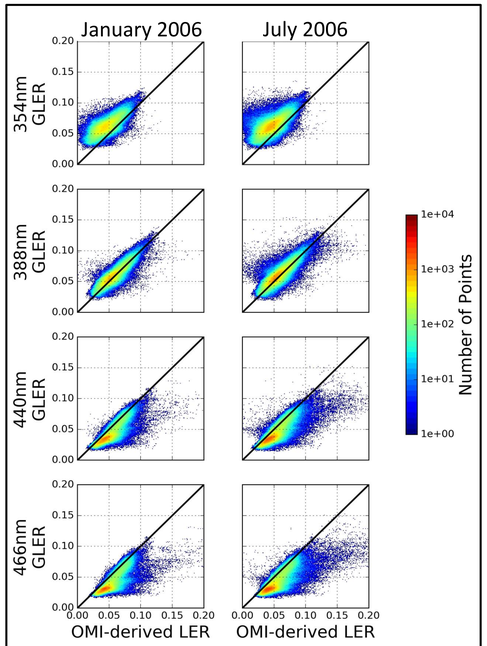


Fig 1: Comparison of OMI-derived LER and GLER in January and July of 2006 over the Pacific Ocean. Data with a co-scattering angle of less than 20° are excluded to avoid sun glint (some weak glint still exists despite screening).

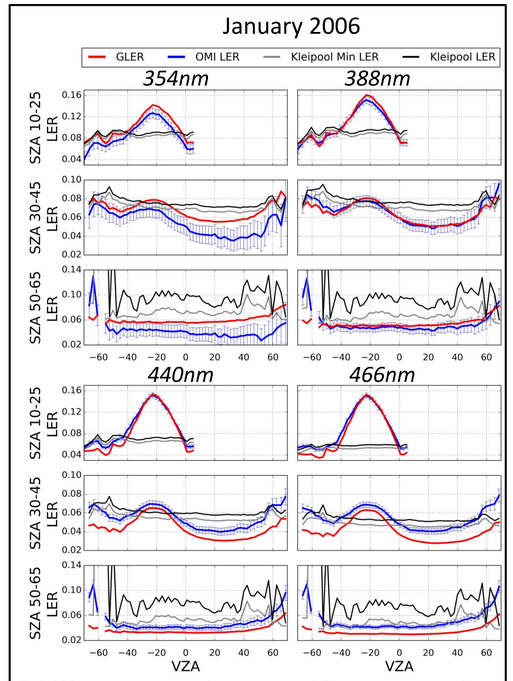


Fig 2: LER as a function of viewing zenith angle (VZA) for select solar zenith angle (SZA) ranges for the Pacific Ocean. Blue error bars represent the 2% calibration uncertainty of OMI (Dobber et al., 2008). Negative VZAs represent the west side of the OMI swath (forward scattering), whereas positive VZAs represent the east side of the OMI swath (backward scattering).

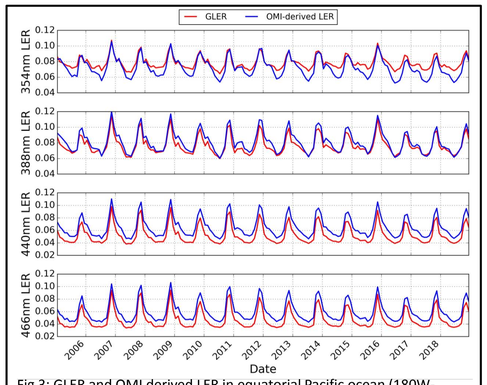


Fig 3: GLER and OMI derived LER in equatorial Pacific ocean (180W-120W, 30S-Eq) for rows 0-10 as a function of time for the OMI mission.

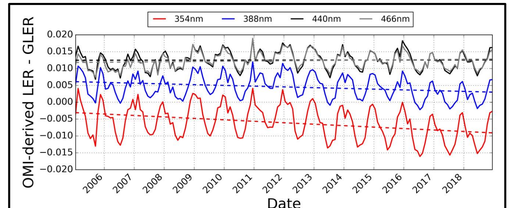
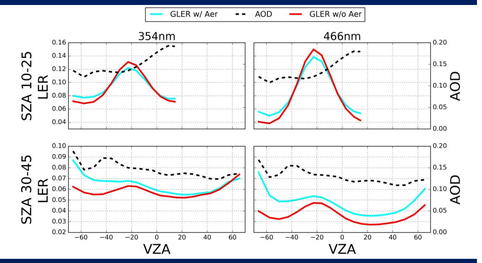


Fig 4: Trend in the difference between OMI-derived LER and GLER for equatorial Pacific ocean (180W-120W, 30S-Eq) for rows 0-10.

Aerosol Simulation

Fig 5: Simulation of GLER including aerosols at 354nm and 466nm for April 10, 2006 orbit 9229 over the Pacific Ocean. Aerosol inputs are from NASA's MERRA-2. No cloud or aerosols screening was used.



Analysis

- GLER reproduces the angular dependence in the measured OMI LER with a wavelength dependent bias up to 0.02 (Figs. 1 and 2)
- GLER follows closely the seasonal and inter-annual variations in LER exhibited by the OMI measurements (Fig. 3)
- OMI and GLER exhibit similar trends through the mission time (Fig. 4) with only small differences in the trend at shorter wavelengths (due to OMI drift?)
- Accounting for aerosols increases the LER most at longer wavelengths (Fig. 5)

Conclusions & Future Work

- The BRDF effect in the OMI-derived LER is captured by GLER with a small bias which can be attributed in part to the effect of background aerosols.
- GLER can replace climatological LER in in trace gas, aerosol, and cloud retrieval algorithms.
- GLER is model based and can be used to detect satellite calibration changes such as instrument drift or striping.
- The model developed for GLER can be used for an atmospheric correction in ocean color retrievals for missions such as PACE.
- In future work we will produce a GLER product for other instruments such as GOME, OMPS, and TROPOMI.

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